45015

# Health Consultation

Perchlorate Contamination in the Sunrise District of the
Sacramento County Water Service

AEROJET GENERAL CORPORATION

RANCHO CORDOVA, SACRAMENTO COUNTY, CALIFORNIA

CERCLIS NO. CAD980358832

JUNE 18, 1998

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

## Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

You May Contact ATSDR TOLL FREE at
1-800-447-1544
or
Visit our Home Page at: http://atsdr1.atsdr.cdc.gov:8080/

# HEALTH CONSULTATION

Perchlorate Contamination in the Sunrise District of the
Sacramento County Water Service

## AEROJET GENERAL CORPORATION

## RANCHO CORDOVA, SACRAMENTO COUNTY, CALIFORNIA

## CERCLIS NO. CAD980358832

Prepared by:

California Department of Health Services
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

## BACKGROUND AND STATEMENT OF ISSUE

The Environmental Health Investigations Branch (EHIB) within the California Department of Health Services (CDHS), under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), is conducting public health assessment activities on the Aerojet-General Corporation (Aerojet) Superfund site in Sacramento County, California (Figure 1, in attachments). A Preliminary Health Assessment written in December 1988 recommended that when additional environmental information and data became available ATSDR would make another assessment (1). A Site Review and Update written in March 1993 also recommended a health assessment be conducted when more data became available (2).

This health consultation is one in a series that will be performed as part of the ATSDR public health assessment process at this site. During this process, data and information on the release of hazardous substances and their impact on public health will be evaluated. Four health consultations have recently been written as part of this series (3-6). CDHS staff are in the process of writing a series of health consultations addressing the perchlorate contamination. In this health consultation, we will focus on describing the perchlorate contamination that has reached the Sunrise District of the Sacramento County Water District (Figure 1) and evaluate the health impact from the exposure that has occurred. We are also in the process of writing several other health consultations that focus on perchlorate exposure to consumers of water from other water purveyors in the area and from private wells in the area. In addition, we are writing a health consultation that describes the perchlorate groundwater contamination west of the Aerojet Superfund site.

Aerojet began operation in 1951. Since that time, Aerojet has manufactured liquid and solid propellants for military and commercial rocket systems and has fabricated, assembled, tested and rehabilitated rocket engines (1). In addition, between 1974 and 1979, Cordova Chemical Company, a wholly-owned subsidiary of Aerojet, manufactured paint components, herbicides, and pharmaceutical products. Over the years, Aerojet and Cordova Chemical disposed of hazardous waste by burial, open burning, discharge into unlined ponds, and injection into deep underground wells (1). Some of these discharges, including perchlorate, have contaminated the environment and have moved off-site of the Aerojet facility boundary (Figure 1). Perchlorate in the groundwater arises from ammonium perchlorate being a main component of solid rocket fuel. In addition to the natural migration of perchlorate-contaminated groundwater from the site, Aerojet is reinjecting treated groundwater, contaminated with perchlorate, at the site's western boundary. The Regional Water Quality Control Board (RWQCB), the California Department of Toxic Substances Control (DTSC) and the U.S. Environmental Protection Agency (USEPA), are the lead regulatory agencies overseeing groundwater investigation and cleanup at Aerojet, and are also investigating other sources of the perchlorate, such as the McDonnell Douglas (now Boeing) and Purity Oil Sales sites.

Sacramento County Sunrise Water Service Area

The County of Sacramento services approximately seven geographical service areas with 18,000 service connections within the county (7). One of these service areas is the Sunrise Water Maintenance District with 350 industrial/commercial connections located in an unincorporated area west of the old McDonnell Douglas site (Figure 2). An estimated 2,000 to 3,000 people work in the Sunrise Water Maintenance District. No residences are serviced by the Sunrise Water Maintenance District. Prior to the discovery of the perchlorate contamination, the water that supplied this area came from two wells (termed SCWMD 17 and 18) located within the water district (Figure 1). SCWMD well 17 is screened from 245 to 315 feet below ground surface (bgs) and well 18 is screened from 190 to 390 feet bgs. Prior to the discovery of the perchlorate problem, the wells were interconnected but the water from each well was distributed primarily to the service connections closest to the well. The primary water demand occurs at night in the summer when the industrial and commercial businesses are watering the landscape.

In 1991, nitrate concentrations in SCWMD well 17 range from 3.8-5.8 ppm and SCWMD well 18 range from 2.5-7.8 ppm. The drinking water standard for nitrate is 45 ppm. SCWMD well 18 became contaminated with trichloroethylene (TCE) and Aerojet and McDonnell Douglas built an air-stripper for this well which was completed in March 1995.

## DISCUSSION

In February 1997, Aerojet, as a part of their ongoing monitoring of certain off-site public drinking water wells, detected perchlorate in five off-site public drinking water wells west of Aerojet. To analyze these water samples, Aerojet used a refined or improved analytical method such that instead of a reporting level of 400 ppb, they were able to obtain a detection limit of 35 ppb.

Of the five wells tested, two wells (wells #17 & #18) served the Sunrise District of the Sacramento County Water Service (Figure 1). In February 1997, the concentrations of perchlorate were 250 and 93 ppb perchlorate in Sacramento County wells #17 and #18, respectively. Subsequent re-testing of the wells showed comparable levels. These detectable levels of perchlorate exceeded the concentration (4 to 18 ppb) suggested by the USEPA provisional reference dose (1 to 5E-4 mg/kg/day) based on a 70 kg individual consuming 2 liters of water a day (8).

The County of Sacramento was not able to shut the two Sunrise District wells off because that would have left the 350 service connections without water (7). However, with the assistance of Aerojet and Arden Cordova Water Service, an emergency project that resulted in an interconnect with the Cordova Water Service Area and a booster station to pump the water was constructed by Sacramento County. This project was finished by February 28, 1997. At that time, County of Sacramento Wells 17 and 18 were placed in a back-up role. The water from the Cordova Water Service Area is generally enough to supply the water needed by the Sunrise Water Maintenance

District; however, well 18 has been brought into service several times in April, May, June, July, and August.

It seems that when well 18 has been used, the water was being used for irrigation. Well #18 is not usually equipped with a data acquisition system to record when the well is being used. In order to address CDHS's concern about the water usage of well #18, Sacramento County Public Works Department placed a pressure recorder on well #18 for a 7-day period beginning on July 17 (18). The pressure recording chart shows a consistent low pressure, ie. high demand, during the nighttime (approximately 10:30PM to 6:30AM).

When the high demand occurs, water from well #18, contaminated with perchlorate above 18 ppb, is added to water distribution system. On July 8th, Sacramento County Department of Public Works sampled water in the system near well #18 at 2:00PM, approximately 10 hours after well #18 had been brought on line to meet the high water demand. Perchlorate was not detected (detection limit = 5.0 ppb) in three water samples (9). While limited, this sampling indicates that the perchlorate-contaminated well water added to the distribution system during night time high demand may not have resulted in exposure to the customers using the water during the daytime. It could be that the three water samples were collected after the perchlorate-contaminated well water was delivered to the user or the perchlorate-contaminated well water was still in the distribution system and it was diluted with intertie water resulting in no detectable levels of perchlorate being delivered to the daytime consumer.

In March 1997, the Sacramento District field staff of the CDHS Division of Drinking Water (DDW) began sampling on a monthly basis the public water sources in the vicinity of the perchlorate contamination. There has been no further testing of Sacramento Sunrise wells because the wells are typically shut off and there is no mechanism that would allow water sampling without turning the well on.

Though DDW staff have not been able to sample wells #17 and #18, DDW staff have sampled other Sacramento County wells in the general direction that the perchlorate groundwater contamination is moving. In March 1997, DDW staff sampled 46 locations, including samples of the irrigation well at the Cordova Gun Club and one monitoring well at 3 depths that Sacramento County had installed in preparation of drilling a new drinking water well to serve a proposed development to the southeast of Douglas Road and Sunrise Boulevard. A detectable but not quantifiable (<4 ppb) amount of perchlorate was found in the Gun Club well (10). No perchlorate was detected in the three depths of the monitoring well (10). In April, DDW staff sampled 22 wells, including two wells that serve the Sacramento County Juvenile Hall, located near the intersection of Bradshaw Road and Kiefer Road. No detectable levels of perchlorate were found in these two wells (10).

Community Concerns

The Sacramento County Public Works staff have shared information about the perchlorate contamination with their customers in the Sunrise District and they report receiving only a few calls regarding this issue.

Sacramento County issued a press release on February 28, 1997 announcing the addition of alternative water supply that allowed them to remove wells 17 and 18 from daily service (see Attachment A). Sacramento County followed this up by a letter that was sent to the Sunrise Water District address and not the water customer billing address, that more clearly addressed the perchlorate contamination problem (see Attachment B). In this letter, Sacramento County notified their Sunrise District water customers of the Arden Cordova Water System meeting to be held on March 18, 1997.

At the March 18th meeting, a panel of experts, invited by Southern California Water Company, presented and responded to the origin of the perchlorate contamination, perchlorate toxicity, and water quality and service issues. Approximately 100 people attended the meeting. The meeting was well covered by the written and television press. The audience had a number of questions and statements concerning water quality, health concerns, water supply, and what was being done to make Aerojet fix the problem. At one point, a woman who has a thyroid problem asked those people in the audience to raise their hand if they had a thyroid problem, and it seemed that a significant portion of the audience responded.

Aerojet sent letters to everyone that attended the March 18th meeting and to people on their mailing list in which they invited interested persons to attend a public meeting on April 17, 1997. The focus of the April meeting organized by Aerojet was thyroid function and perchlorate toxicity. At this meeting, CDHS cooperative agreement staff responded to requests for health studies raised by the community by announcing that we were pursuing a review of available health statistics. After the meeting, CDHS cooperative agreement staff were approached by several concerned people, including a medical director of a company with a large number of employees working within the Cordova Water Service Area. The medical director was interested in getting as much information about perchlorate toxicity as possible and requested a fact sheet about perchlorate toxicity that could be shared with the employees.

Sacramento County Supervisor Nottoli, the county supervisor who represents the Rancho Cordova area, asked state (California Environmental Protection Agency headquarter staff, State Water Resources Control Board, Regional Water Quality Control Board, Office of Environmental Health Hazard Assessment, Department of Toxic Substances Control, and Department of Health Services) and county (Environmental Health, Base Closure, Public Works) to attend a meeting intended to brief him about the situation. At the meeting on April 11, 1997, Supervisor Nottoli began the meeting by asking each of the state and county staff to introduce themselves and explain their responsibility in dealing with the perchlorate. After hearing all of the different involvement, he encouraged everyone to work closely together. He indicated that his

constituency seemed confused and he stressed that the community needed to get information often and in an understandable format, the basic question they wanted to know, "Is it safe to drink the water?".

In April, CDHS cooperative agreement staff prepared a draft of a fact sheet focusing on perchlorate and health issues (see Attachment C). CDHS cooperative agreement staff asked for comments on a draft fact sheet from DDW staff, RWQCB staff, and all water purveyors including Sacramento County Public Works Department staff. CDHS made the final perchlorate fact sheet available in hard copy to Sacramento County Public Works.

Sacramento County sent a letter dated June 20, 1997 to the water customers billing address letting them know that the Sacramento County Sunrise District wells (17 and 18) had been intermittently activated in April and May due to high water demand (see Attachment D). The following is an excerpt: "The peak demand in the service area generally occurs between midnight and 7 a.m. as the result of irrigation, and it is therefore reasonable to assume that this is how most of the well water is used. Furthermore, the well water is blended in the system with uncontaminated water from Arden Cordova, thereby reducing the concentration of perchlorate. Nonetheless, it is possible that some of our customers, particularly those close to the Recycle Road Well site, may have been exposed to drinking water with a perclorate concentration considerably higher than the provisional action level of 18 ppb." Sacramento County sent the perchlorate fact sheet developed by CDHS with the letter.

Exposure Pathway

It is not clear when the perchlorate contamination reached the Sacramento County Sunrise District wells, because Aerojet had previously been using an analytical method to monitor for perchlorate that was not sensitive enough to adequately assess the migration of perchlorate. In fact, until recently, Aerojet had a perchlorate reporting level to RWQCB of 400 ppb, based on the fact that the older method had a practical quantitation limit for perchlorate of 400 ppb (11). It was not until Aerojet improved upon the analytical method they had been using and were able to obtain lower detection limits, that the perchlorate contamination could be adequately addressed.

Though we do not have good monitoring information, we do know that Aerojet began reinjecting water from their treatment plants on the west boundary of the site in 1984 and 1985 (12). Thus, assuming that it took a couple of years for the perchlorate to move from the reinjection wells to the Sunrise District wells, perchlorate has probably been a contaminant in the Sunrise District wells since 1987.

The exposure to the perchlorate contamination in wells #17 and #18 was supposed to have ceased on February 28, 1997, when the intertie with the Arden Cordova Water Service went on-line. However, due to high water demand during the summer months, well #18 has been brought into service on occasion. As described in the Background Section, well #18 is brought into service during the night time when the businesses are irrigating their landscapes and very few people may

be using the water for drinking water purposes. Additionally, water testing, the day after well #18 was brought into service, did not detect any perchlorate in the water being delivered to the daytime user. Nevertheless, it is possible that some Sunrise District water users did receive perchlorate-contaminated well water during the months of May, June, and July. When the intertie with the Mather Base Family Housing System is brought on-line (maybe October), there should be enough water to meet the demand and thus, no further perchlorate exposures should occur to customers of the Sunrise District.

The two Sunrise District wells provide water to 350 commercial connections. The businesses include gas service stations, restaurants, manufacturing industries, and commercial buildings. The fast food restaurants tend to be located closer to White Rock Road and thus probably received water from well #17 when it was in use. The number of people potentially exposed is very difficult to determine. Many exposures likely occurred over a short duration resulting in a very low dose to the customers and visitors who occasionally frequented the business establishments. On the other hand, employees of the businesses may have been exposed on a regular basis to the perchlorate when they drank water and washed or showered with the water.

For a target population to be exposed to environmental contamination, there must be a mechanism by which that contamination comes into direct contact with the target population (12). An exposure pathway is the description of this mechanism. A completed exposure pathway consists of five parts: a source of contamination, an environmental medium and transport mechanism, a point of exposure, a route of exposure, and a receptor population. For a population to be exposed to an environmental contamination, a completed exposure pathway (all five elements) must be present.

In the next few paragraphs, CDHS will describe how we evaluated the completed exposure pathway related to the perchlorate contamination of the Sunrise District well water for two different receptor populations: worker exposure at Sunrise District businesses and exposure to a frequent adult customer or visitor to Sunrise District businesses (Table 1).

When evaluating the potential health impact from exposure to contaminated potable water, CDHS considered all routes of exposure to perchlorate in the water. The most important route of exposure is through ingestion of the water. We did not evaluate exposure from eating homegrown fruits and vegetables that were irrigated with perchlorate-contaminated water, because there are no residential or agricultural uses of the Sunrise District water. We did not evaluate inhalation exposure to perchlorate in the potable water because perchlorate is not volatile (does not become a gas).

For certain chemicals, skin contact with contaminated water can be an important route of exposure. Generally speaking, skin absorption of a chemical is based on how much that chemical likes to be in fat-like surroundings. Inorganic ions like perchlorate do not like being in fat-like surroundings and thus their uptake by the skin, a fat-like environment, are typically less than 10% and frequently less than 1%. Since the permeability characteristic for perchlorate is not known,

we used the permeability characteristic of another anion, chloride ($1 \times 10^{-10}$ cm/sec) to evaluate skin exposure to perchlorate (13). We found that skin contact would result in an exposure dose estimate that is less than 0.0005% of the dose estimate that would be received by ingesting the water. Therefore, CDHS focused on ingestion in calculating dose estimates.

The amount of Sunrise District perchlorate contaminated water that is ingested will be determined for each exposure pathway; however, when the route of exposure is ingestion, it will be assumed that there is 100% absorption of perchlroate into the body from the gut from the amount water that is ingested.

Toxicological Evaluation

This health consulation is focuses on perchlorate exposure and thus the toxicological evaluation will focus on perchlorate. CDHS acknowledges that there are low levels (below the drinking water standard) nitrates and nitrite, naturally-occurring and agriculturally-related, in the well water; however, the affect of nitrates/nitrites in combination with perchlorate will not be evaluated due to lack of toxicological information that would allow such an evaluation.

Most of the information about the toxicity of perchlorate comes from studies of potassium perchlorate as a treatment for hyperthyroidism, resulting from Graves' Disease. Perchlorate inhibits the secretion of thyroid hormones (and can thus relieve the symptoms of Graves' Disease) by competitively inhibiting the accumulation of iodide in the thyroid (14). Discontinued administration of the ammonium perchlorate to Graves' Disease patients does result in a return to their hyperthyroid condition (15). People who have been treated with perchlorate have reported gastrointestinal irritation, skin rash, and hematological effects including agranulocytosis, aplastic anemia, and lymphadenopathy (14). The severe hematological effects seem to be more likely to occur when large doses of more than 1,000 mg/day (approximately 14 mg/kg/day for a 154 pound man) are used (16).

Potassium perchlorate was extensively used for treatment of Graves' Disease patients in the late 1950s and 1960s. After the reports of the severe hematological effects, potassium perchlorate was not used for many years (17). In the early 1980s, physicians in Europe began using it again for the treatment of Graves Disease, and reporting no serious side effects occurring as long as the dose was kept below 1,000 mg/day (approximately 14mg/kg/day for a 154 pound man) (16). In addition, potassium perchlorate has also been found helpful in treating thyrotoxicosis resulting as a side effect from other drug therapies (18-22).

There are only a few studies of the short-term exposure in persons without Graves Disease (23). The animal studies that have been conducted have also involved short-term exposures and the doses were too high to see a level where there was no effect on the thyroid. Both human and animal studies have primarily examined the effects of perchlorate on the thyroid, interference with the production of thyroid hormones resulting in a below normal level of thyroid hormone in

circulation (hypothyroidism). The effect of perchlorate on systems other than the thyroid needs to be explored, especially, effects on the blood system (described above) and developmental effects (described below).

Children are not little adults, their bodies are not fully developed, and may not respond to a perchlorate in the same manner as an adult. For instance, thyroid hormone is critical to normal brain and physical development, and the critical period for this dependency on thyroid hormone begins in the uterus and extends up until three years of age. After the age of 3, thyroid hormone continues to play a primary role in physical development until puberty. Thus, a low level or absence of thyroid hormone in utero or in childhood may lead to irreversible mental retardation and retarded physical growth.

Perchlorate can cross the placenta and thus could affect the developing fetus, though these effects have not been studied in humans. It is known, however, that drugs currently being used to treat Graves' Disease such as propylthiouracil do cross the placenta and can produce neonatal hypothyroidism (24, 25) and fetal in utero goiter (enlargement of the thyroid) (26-28). In fact, because the developing fetus's thyroid is immature, propylthiouracil is a more potent suppressor of thyroid function in the fetus than in the mother (29).

In a study of the effects of potassium perchlorate (740mg/kg/day for the mother) fed to pregnant guinea pigs during pregnancy, a 15-fold enlargement of thyroid of the newborns was noted, even though no increase in size of the mother's thyroids occurred (30). Thyroid hormone levels of the newborn guinea pig were not measured in this study. Another animal study in which the mother was given fairly high levels of perchlorate, also resulted in increased thyroid weight in the offspring and the mother (31). At this time, it is unclear whether lower doses of perchlorate would affect the thyroid of the developing fetus and young child and thus affect thyroid function at a time when normal thyroid hormone production is important to brain development.

There are animal studies underway which are exploring the toxicity of perchlorate, including effects on the immune system and developmental effects (see the Recommendations section at the end of the text for more information).

In 1992 and 1995, USEPA staff reviewed the perchlorate toxicology studies and derived a provisional reference dose (RfD) (8, 23). An RfD is a dose to which a person could be exposed over long-term period without having any appreciable risk of a noncancer health effect. The USEPA applied an uncertainty factor of 300 or 1000 to the No Observable Adverse Effect Level of 0.14 mg/kg/day (NOAEL) (23, 32) to derive an RfD of 1 to 5 x 10-4 mg/kg/day (8). (If one assumes that a person drinks 2 liters/day of water and weighs 70 kilograms, the reference dose range corresponds to an acceptable range of perchlorate in drinking water of 4 to 18 ppb).

The uncertainty factor of 300 or 1000 is derived from multiplying the following (8):

* An uncertainty factor of 10 to account for extrapolation from the acute exposure in the NOAEL study to chronic exposure of an RfD;

* An uncertainty factor for database deficiencies (3 or 10) to account for data limitations including limited data on subchronic and chronic exposure to low doses of perchlorate, limited data on other organ system effects, limited data on the effects on the hematopoietic system, and a lack of reproductive and multigenerational data;

* An uncertainty factor of 10 to protect sensitive subpopulations which would include groups such as hypothyroid patients and individuals with low iodine diets or with genetically impaired iodine accumulation.

The only information about the possible carcinogenicity of perchlorate has to do with cancers of the follicular thyroid cells (8). Interference with the normal thyroid-pituitary feedback mechanism, such as that caused by perchlorate, can theoretically lead to thyroid follicular cell neoplasia. Several animal studies found that thyroid tumors were induced in both rats and mice by long-term administration of high doses of perchlorate. However, humans are not supposed to be as sensitive as the rat to thyroid cancer (33, 34). Since perchlorate's possible carcinogenic effects on the thyroid are based on the same mechanism (interfering with the thyroid-pituitary homeostasis) that determines its noncarcinogenic effects, it may be appropriate to consider the RfD as a dose which does not pose a significant risk of thyroid cancer (23).

It is even harder to determine whether or not perchlorate exposure can cause any other type of cancer. If a link is discovered, it will probably be based on perchlorate acting not as a mutagen (causing genetic changes) but rather as a growth promoter, an effect associated with a threshold. In other words, below a certain threshold, perchlorate would not have cancer-causing effects. More toxicological information is needed to ascertain whether perchlorate can cause cancer and if it can, at what dose this effect may start occurring.

Using USEPA's provisional reference dose (0.0001 to 0.0005 mg/kg/day) based on perchlorate's effect on the thyroid, CDHS evaluated the noncancer (thyroid) health impact of the completed exposure pathway, drinking perchlorate-contaminated water from the Sunrise District wells, for two receptor populations: worker and frequent adult customer/visitor to a Sunrise District business (Table 1).

Though it is possible to estimate a dose for a child who visits a business served by the Sunrise District service area and drinks the water, CDHS did not calculate this dose because we are not confident about how to interpret the dose estimate. To compare the estimate of a child's dose with toxicological information based on adult exposure ignores the fact that a child is not a small adult, especially when it comes to the importance of the thyroid in normal brain development (see above). Thus, until there is more information about perchlorate's effect on children, CDHS is not able to evaluate past exposures to a young child drinking theSunrise District water.

**Worker exposure at Sunrise District businesses:** CDHS estimated the exposure for a worker who works eight hours a day, five days a week, for 50 weeks of the year (assumes a two week vacation) at a business that is served by the Sacramento County Sunrise Water Maintenance District (Table 2 is a list of the exposure parameters used in the toxicological evaluation). CDHS assumed that the worker is involved in manual labor and thus drank a relatively large quantity of water (3.7 liters/day, equivalent to 15.6 cups/day) (35). CDHS estimated the dose based on the worker being exposed to water coming from both Sacramento County Sunrise District well (wells #17 and 18), with contamination levels of 280 ppb and 93 ppb, respectively.

The estimated doses for worker exposure to water from well #17 (0.0041 mg/kg/day) or well #18 (0.0014 mg/kg/day) exceed the provisional reference dose range (0.0001 to 0.0005 mg/kg/day) which means that noncancer (thyroid depression) health effects may have occurred when workers in the Sunrise District were exposed to water from these wells. However, because there is a very large uncertainty factor associated with the provisional reference dose and the estimated doses do not approach the NOAEL (0.14 mg/kg/day), it is unlikely that these exposures did cause any noncancer health effects.

**Frequent adult customer or visitor exposure at Sunrise District businesses:** CDHS estimated the exposure for an adult visitor or adult customer who goes once a day, five days a week, for 50 weeks of the year (assumes a two week vacation) to a business that is served by the Sacramento County Sunrise Water Maintenance District (Table 2 is a list of the exposure parameters used in the toxicological evaluation). CDHS assumed that the adult visitor/customer drinks one cup of water (0.24 liters) per trip to the business. CDHS estimated the dose based on the frequent adult customer/visitor being exposed to water coming from both Sacramento County Sunrise District well (wells #17 and 18), with contamination levels of 280 ppb and 93 ppb, respectively.

The estimated dose for the frequent adult customer/visitor exposed to water from well #17 (0.0007 mg/kg/day) exceeds the provisional reference dose range (0.0001 to 0.0005 mg/kg/day). This means that noncancer (thyroid depression) health effects may have occurred to the frequent adult customer/visitor who drank water coming from well #17. However, because there is a very large uncertainty factor associated with the provisional reference dose and the estimated dose does not approach the NOAEL (0.14 mg/kg/day), it is highly unlikely that exposure to perchlorate-contaminated water from well #17 caused any noncancer health effects to the frequent adult customer/visitor drinking or washing with that water.

The estimated dose for the frequent adult customer/visitor exposed to water from well #18 (0.0002 mg/kg/day) does not exceed the provisional reference dose range (0.0001 to 0.0005 mg/kg/day). This means that noncancer (thyroid depression) health effects would not have occurred to the frequent adult customer/visitor drinking or washing with water from well #18.

## CONCLUSION

Based upon the information reviewed, there was a completed exposure pathway to perchlorate-contaminated water in the Sacramento County Sunrise Water Maintenance District. There are no residences located in the Sunrise Maintenance District. Many exposures likely occurred over a short duration resulting in a very low dose to the customers and visitors who occasionally frequented the business establishments. On the other hand, employees of the businesses may have been exposed on a regular basis to the perchlorate when they drank water and washed or showered with the water.

It is hard to say when the perchlorate first contaminated the Sunrise District wells but it may have been as early as 1987. Since late February when the Arden Cordova System intertie was brought online, there have been intermittent exposures that could possibly have occurred in the southern portion of the Sunrise District when high demand kicked well #18 online. When the intertie with Mather Family Housing comes online, exposure to perchlorate contaminated water should no longer be occurring in the Sunrise District because perchlorate-free water from the Mather Family Housing and Arden Cordova water systems should be able to meet the water demands for the Sunrise District.

The perchlorate concentration in the two Sunrise District drinking water wells exceeded a concentration (4 to 18 ppb) suggested by the USEPA provisional reference dose based on a 70 kg individual consuming two liters of water a day. There is currently a three hundred to thousand-fold uncertainty factor incorporated into the provisional reference dose. Since the uncertainty factors are supposed to account for the somewhat limited toxicological information, it is conceivable that as more toxicological data becomes available, a change in the (provisional) reference dose may occur.

The estimated doses for a Sunrise District worker exposed to water from well #17 or well #18 and the estimated dose for a frequent adult customer/visitor to a Sunrise District business who drank water from well #17 exceed the provisional reference dose range which means that noncancer (thyroid depression) health effects may have occurred when the workers or frequent adult customers/visitors in the Sunrise District were exposed to water from these wells. However, because there is a very large uncertainty factor associated with the provisional reference dose and the estimated doses do not approach the NOAEL, it is unlikely that these exposures did cause any noncancer health effects.

The estimated dose for the frequent adult customer/visitor exposed to water from well #18 does not exceed the provisional reference dose range. This means that noncancer (thyroid depression) health effects would not have occurred to the frequent adult customer/visitor drinking or washing with water from well #18.

Based upon the information available at the time this health consultation was written, CDHS concludes that well water from Sacramento County Sunrise Water Maintenance District well #17 and #18 may pose a health threat to the users of that water.

## PUBLIC HEALTH RECOMMENDATIONS AND ACTIONS

The Public Health Recommendations and Actions Plan (PHRAP) for this site contains a description of actions taken, to be taken, or under consideration by ATSDR and CDHS at and near the site. The purpose of the PHRAP is to ensure that this health consultation not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. The CDHS and ATSDR will follow-up on this plan to ensure that actions are carried out.

### Actions Completed

1. Sacramento County Public Works Department with assistance from Arden Cordova, Aerojet, and Mather Air Force Base, and others, provided an alternative, and perchlorate-free water supply to the Sunrise Water Maintenance District.

2. CDHS prepared a fact sheet about perchlorate and health. CDHS made this fact sheet available to the affected water purveyors including the Sacramento County Public Works Department.

3. Sacramento County Public Works Department has communicated with the Sunrise District water customers on several occasions, including distributing the perchlorate fact sheet developed by CDHS cooperative agreement staff.

### Actions Planned:

1. The Air Force and the Perchlorate Study Group (a number of manufacturers and users of perchlorate) are sponsoring an investigation into fate and transport questions regarding perchlorate. For instance, they will investigate if is perchlorate is taken up and bioconcentrated by vegetable crops and the skin permeability of perchlorate.

2. The Air Force and the Perchlorate Work Group are also sponsoring a series of animal studies to address some of the information lacking in understanding perchlorate toxicology. CDHS cooperative agreement staff along with other state and federal scientists, were asked by the Air Force to recommend and oversee the planning of the animal studies. As of August 1997, the study protocols have been finalized and the process of choosing a laboratory to conduct the studies is underway. A report on the studies is expected in mid-summer 1998.

**Recommendations for Further Action:**

1. Use Sacramento County Sunrise District wells #17 and 18 for fire protection only until perchlorate levels fall below the 18 ppb.

2. Continue communicating with the Sunrise District water customers about the perchlorate issue.

3. If indicated based on new toxicological information, review toxicological evaluation of past and current perchlorate exposures in the Sunrise District.

## REFERENCES


1. U.S. Agency for Toxic Substances and Disease Registry, Division of Health Assessment and Consultation. Preliminary Health Assessment of the Aerojet-General Corporation, Rancho Cordova, CA. December 5, 1988.

2. Environmental Health Investigations Branch California Department of Health Services. Site Review and Update of the Aerojet-General Corporation, Rancho Cordova, CA. Prepared for U.S. Agency for Toxic Substances and Disease Registry. March 19, 1993.

3. Environmental Health Investigations Branch California Department of Health Services. Health Consultation- American River Study Area of the Aerojet-General Corporation, Ranch Cordova, CA. Prepared for U.S. Agency for Toxic Substances and Disease Registry. February 21, 1996.

4. Environmental Health Investigations Branch California Department of Health Services. Health Consultation- Review of Methods of Analysis for the Perchlorate Anion, Aerojet-General Corporation, Rancho Cordova, CA. Prepared for U.S. Agency for Toxic Substances and Disease Registry. March 18, 1997.

5. Environmental Health Investigations Branch California Department of Health Services. Health Consultation- Hazel Avenue Ponds near the Aerojet-General Corporation, Rancho Cordova, CA. Prepared for U.S. Agency for Toxic Substances and Disease Registry. November 18, 1996.

6. Environmental Health Investigations Branch California Department of Health Services. Health Consultation- Trichloroethylene Levels in Private Wells near the Aerojet-General Corporation, Rancho Cordova, CA. Prepared for U.S. Agency for Toxic Substances and Disease Registry. July 1996.

7. Senior Civil Engineer, Sacramento County Water Resources Division. Office meeting, concerning Sunrise System Description and Perchlorate Contamination. July 8, 1997.

8. Associate Director, National Center for Environmental Assessment, U.S. Environmental Protection Agency. Letter with attached report written to the Chairman of the Perchlorate Study Group, concerning Review of Proposed RfD for Perchlorate. October 23, 1995.

9. Water Resources Division Senior Civil Engineer, Sacramento County Public Works Agency, Water Resources Division. Letter to Staff Toxicologist, California Department of Health Services, Environmental Health Investigations Branch, concerning Perchlorate Contamination in Sacramento County. August 4, 1997.

10. California Department of Health Services, Drinking Water Field Operations Branch, Sacramento. Perchlorate Monitoring Data: 3/11/97 through 6/23/97. July 25, 1997.

11. California Regional Water Quality Control Board, Central Valley Region. Consent Decree with Aerojet-General Corporation Inc. July 1988.

12. ATSDR. Public Health Assessment Guidance Manual. Lewis: Boca Raton, 1993.

13. Y. Toyoshima and T.E. Thompson. 1975. Chloride flux in bilayer membranes: chloride permeability in aqueous dispersions of single walled vesicles. Biochemistry. 14: 1525-1531.

14. Toxicology Excellence for Risk Assessment. Proposed Perchlorate Reference Dose (RfD), Peer Review Draft. Prepared for The Perchlorate Study Group. February 1997.

15. J.M.C. Connell. 1981. Long-Term Use of Potassium Perchlorate. Postgraduate Medical Journal. 57: 516-517.

16. K.W. Wenzel and J.R. Lente. 1984. Similar effects of thioamide drugs and perchlorate on thyroid-stimulating immunoglobulins in Graves' Disease: Evidence against an immunosuppressive action of thionamide drugs. J Clin Endocrinol Metab. 58: 62-69.

17. D. Barzilai and M. Sheinfeld. 1966. Fatal complications following use of potassium perchlorate in thyrotoxicosis: report of two cases and a review of the literature. Isr J Med Sci. 2: 453.

18. E. Martino, F. Aghini-Lombardi, S. Mariotti, M. Lenziardi, L. Baschieri, L.E. Braverman and A Pinchera. 1986. Treatment of amiodarone associated thyrotoxicosis by simultaneous administration of potassium perchlorate and methimazole. J Endocrinol Invest. 9: 201-207.

19. E. Martino, S. Mariotti, F. Aghini-Lomardi, M. Lenziardi, S. Morabito, L. Baschieri, A Pinchera, L. Braverman and M. Safran. 1986. Short term administration of potassium perchlorate restores euthyroidism in amiodarone iodine-induced hypothyroidism. J Clin Endocrinol Metab. 63: 1233-1236.

20. E.W.C.M. van Dam, M.F. Prummel, W.M. Wiersinga and R.E. Nikkels. 1993. Treatment of amiodarone-induced hypothyroidism with potassium perchlorate. Neth J Med. 42: 21-24.

21. L.J.M. Reichert and H.A.M. De Rooy. 1989. Treatment of amiodarone induced hyperthyroidism with potassium perchlorate and methimazole during amiodarone treatment. Brit Med J. 298: 1547-1548.

22. M.D. Trip, D.R. Duren and W.M. Wiersinga. 1994. Two cases of amiodarone-induced thyrotoxicosis successfully treated with a short course of antithyroid drugs while amiodarone was continued. Br Heart J. 72: 266-268.

23. Associate Director, Environmental Criteria and Assessment Office, U.S. Environmental Protection Agency. Memorandum to Toxicologist , U.S. Environmental Protection Agency, Region IX, concerning Provisional Non-cancer and Cancer Toxicity Values for Potassium Perchlorate (CASRN 7778-74-7) (Aerojet General Corp./CA). December 2, 1992.

24. S.C. Werner. 1967. Hyperthyroidism in the pregnant woman and neonate: two discussions on hyperthyroidism. J Clin Endocrinol Metab. 27: 1637-1654.

25. A.R. Frisk and E. Josesson. 1947. Thiouracil derivatives and pregnancy. Acta Med Scand (Suppl). 196: 85-91.

26. K. Sato, H. Mimura, S. Kato, O. Isozaki, T. Tsushima and K. Shizume. 1983. Serum propylthiouracil concentration in patients with Graves' disease with various clinical courses. Acta Endocrinol (Copenh). 104: 189-194.

27. S. Retetoff, Y. Ochi, H.A. Selenkow and R.L. Rosenfeld. 1974. Neonatal hypothyroidism and goiter in one infant of each of two sets of twins due to maternal therapy with antithyroid drugs. J Pediatr. 85:

28. G.N. Burrow. 1965. Neonatal goiter after maternal propylthiouracil therapy. J Clin Endocrinol Metab. 25: 4039-4040.

29. J.G. Thorpe-Beeston and K.H. Nicolaides. Maternal and Fetal Thyroid Function in Pregnancy. The Parthenon Publishing Group: New York, 1996.

30. S. Postel. 1957. Placental transfer of perchlorate and triiodothryronine in the guinea pig. Endocrinol. 60: 53-66.

31. K Brown-Grant and M.R. Sherwood. 1971. Viability of the rat blastocyst following the oral administration of potassium perchlorate or potassium iodide to the mother. J Reprod Fert. 27: 265-267.

32. J.B Stanbury and J.B. Wyndaarden. 1952. Effect of Perchlorate on the Human Thyroid Gland. Metabolism. 1: 533-539.

33. M. Karstadt and J.K. Haseman. 1997. Effect of discounting certain tumor types/sites on evaluations of carcinogenicity in laboratory animals. American Journal of Industrial Medicine. 31: 485-494.

34. C. C. Capen. 1994. Mechanisms of chemical injury of thyroid gland. Prog Clin Biol Res. 387: 173-191.

35. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. Exposure Factors Handbook. July 1989.

36. H Schaefer and T.E. Redelmeier. Skin Barrier: Principles of Percutaneous Absorption. Karger: Basel, 1996.

## PREPARERS OF REPORT

### ENVIRONMENTAL AND HEALTH EFFECTS ASSESSORS:

Marilyn C. Underwood, Ph.D.
Staff Toxicologist
Environmental Health Investigation Branch
California Department of Health Services

### COMMUNITY RELATIONS COORDINATOR:

Jane Riggan, M.S.W.
Public Health Social Work Consultant II
Environmental Health Investigations Branch
California Department of Health Services

### ATSDR REGIONAL REPRESENTATIVES

William Nelson
Gwendolyn Eng
Dan Strausbaugh
Regional Representatives, Region IX
Agency for Toxic Substances and Disease Registry

### ATSDR TECHNICAL PROJECT OFFICER:

William Greim, M.S., MPH
Environmental Health Scientist
Division of Health Assessment and Consultation
Superfund Site Assessment Branch, State Programs Section

CERTIFICATION

The Perchlorate Contamination in the Sunrise District of the Sacramento County Water Service, Aerojet-General Corporation Health Consultation was prepared by the California Department of Health Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun.

Technical Project Officer, SPS, SSAB, DHAC

The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation, and concurs with its findings.

Chief, SPS, SSAB, DHAC, ATSDR

**Table 1. Perchlorate Contamination in the Sunrise District-Completed Exposure Pathway for Different Receptor Populations**

| Receptor Group Pathway Name | Source | Environmental medium | Point of Exposure | Route of Exposure | Exposed Population | Time |
|---|---|---|---|---|---|---|
| Worker exposure at Sunrise District businesses | Aerojet, McDonnell Douglas (?) | Groundwater wells in the Sunrise District | Business Tap | Ingestion | Workers | Past (Current) |
| Frequent customer or visitor to Sunrise District businesses | Aerojet, McDonnell Douglas (?) | Groundwater wells in the Sunrise District | Business Tap | Ingestion | Frequent customer, Frequent visitor | Past (Current) |

**Table 2. Exposure Factors for Each Receptor Group of the Completed Exposure Pathway in the Sunrise District**

| Pathway Name | Exposure Parameter | Value |
|---|---|---|
| **Worker exposure at Sunrise District businesses** | Ingestion Rate | 3.7 liters (15.6 cups)/day |
| | Body Weight | 70 kilograms (154 pounds) |
| | Exposure Frequency | 8 hours/day<br>5 days/week<br>50 weeks/year |
| | Averaging factor | 365 days/year |
| **Frequent customer or visitor to Sunrise District businesses** | Ingestion Rate | 0.24 liter (1 cup)/visit |
| | Body Weight | 70 kilograms (154 pounds) |
| | Exposure Frequency | 5 visits/week<br>50 weeks/year |
| | Averaging factor | 365 days/year |

**Figure 1**
**Perchlorate Groundwater Plume in Relation to**
**Aerojet and Sacramento County Sunrise Water System**

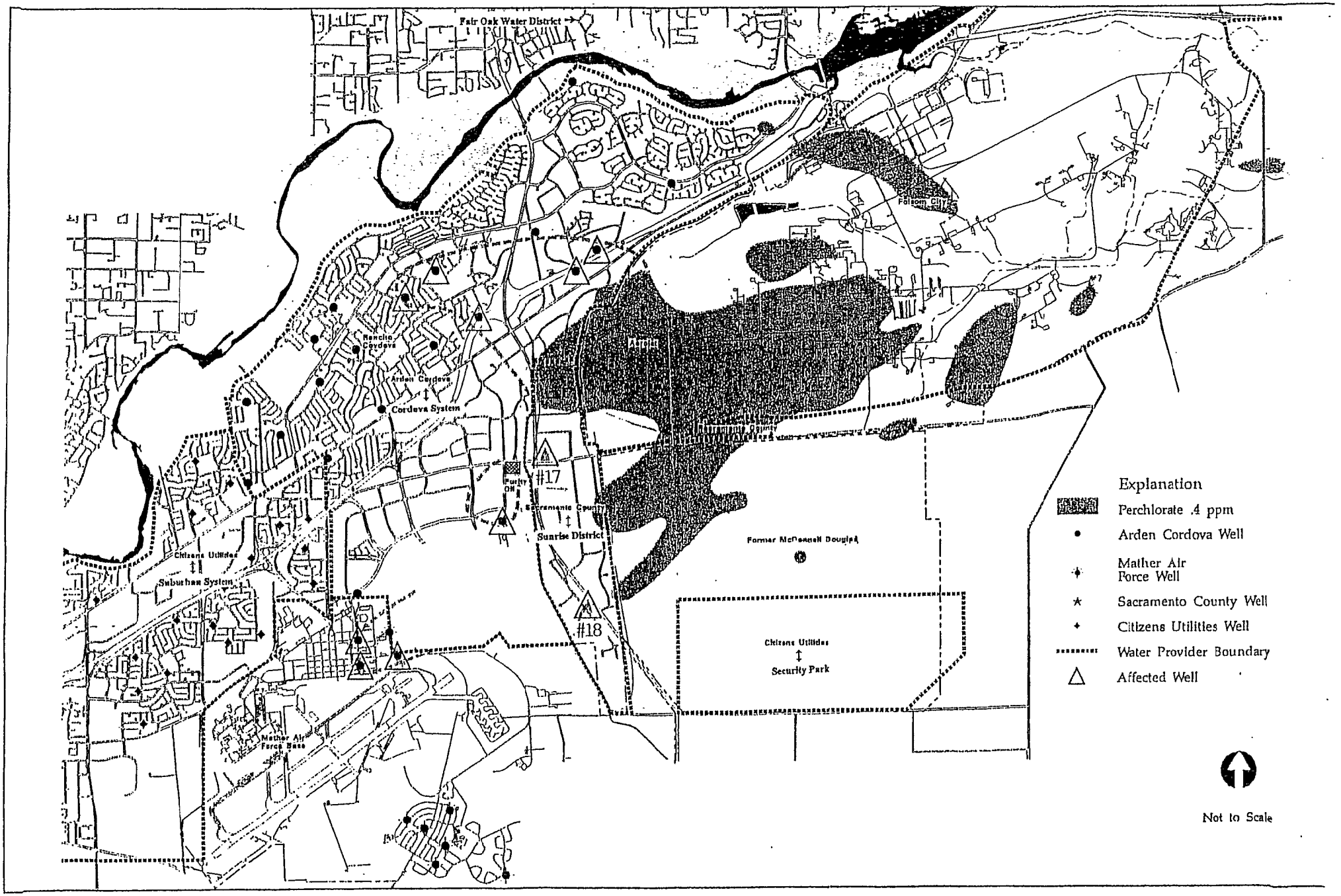
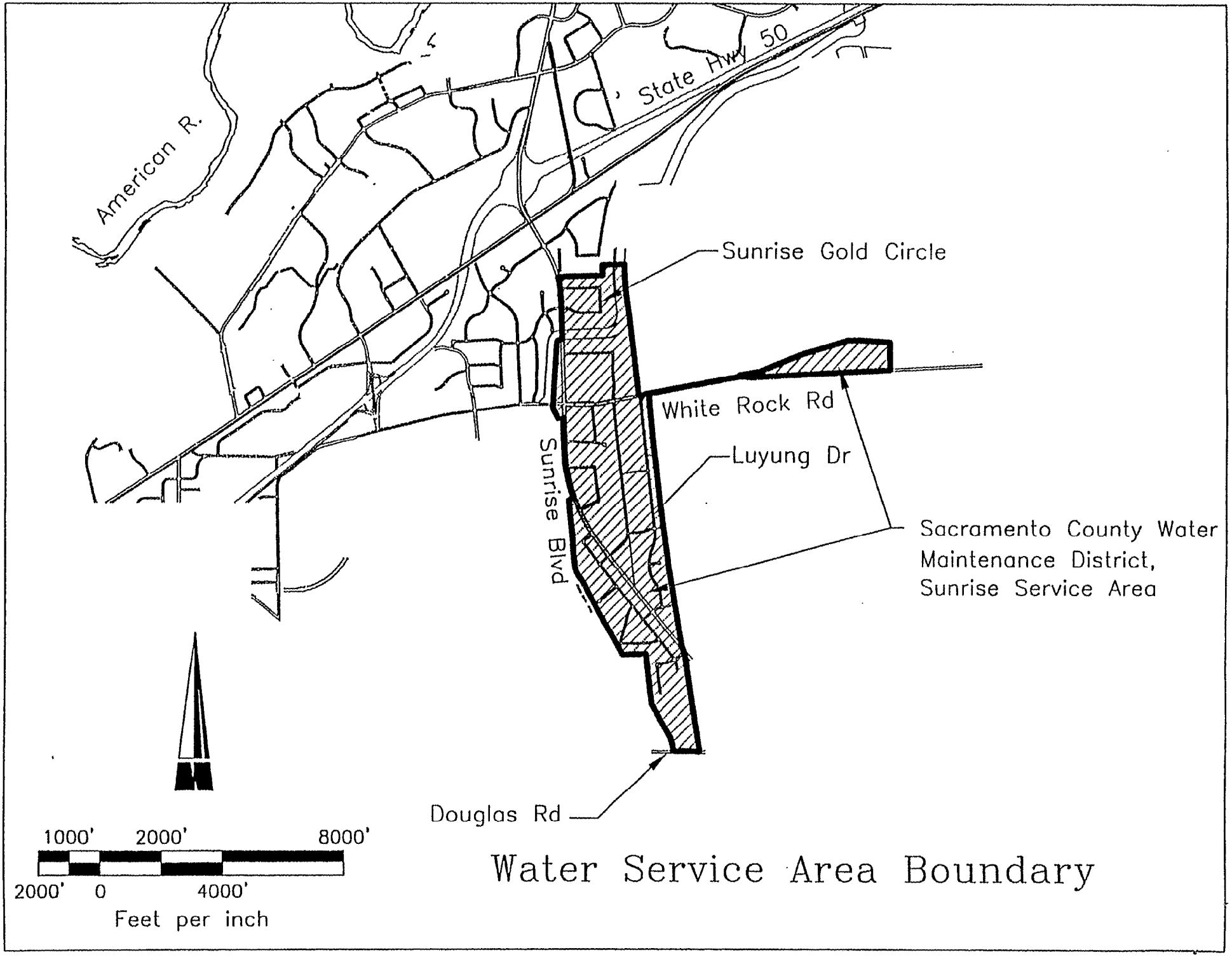


Figure 2
Sunrise Water System Service Area




affected.dwg

Attachment A

PUBLIC WORKS AGENCY

WARREN H. HARADA, Administrator
PATRICK L. GROFF, Director
Public Works Administration
ROBERT F. SHANKS, Director
District Engineering
TERRY T. TICE, Director
County Engineering

# COUNTY OF SACRAMENTO

WATER RESOURCES DIVISION.....KEITH DEVORE, Chief
Operation and Maintenance Engineering
9660 Ecology Lane
Sacramento, California 95827-3881
Phone: (916) 440-6851
Fax: (916) 875-6884

Date: February 28, 1997

Contact: John Coppola
875-6867

Michele McCormick
736-6900

FOR IMMEDIATE RELEASE

## WATER SUPPLY CHANGED FOLLOWING CHEMICAL DETECTION

At the recommendation of the State Department of Health Services (DHS), new water supplies have been provided for some 350 Sacramento County commercial and industrial water customers along Sunrise Boulevard in Rancho Cordova. The action was taken following the detection of perchlorate in two County wells.

Perchlorate is not among those chemicals for which DHS requires testing, but the Department does consider the chemical to be "suspect".

The chemical was discovered during specialized testing conducted by Aerojet, and the purveyors were notified on February 11. DHS did not require or recommend any immediate action.

There is no current risk standard for perchlorate, although the Environmental Protection Agency is reviewing toxicity data, particularly regarding any potential affect on thyroid activity in infants and young children. Perchlorate is scheduled for further status review by the EPA later this month.

Affected customers of the Sacramento County Water District will be individually notified within a few days. For further information on water supply, County customers may call 875-5555.

Those seeking additional information regarding ammonium perchlorate and its potential health affects should call DHS or their physician.

# # #

Attachment B

PUBLIC WORKS AGENCY

WARREN H. HARADA, Administrator
ROBERT F. SHANKS, Director
District Engineering
TERRY T. TICE, Director
County Engineering

# COUNTY OF SACRAMENTO

WATER RESOURCES DIVISION.....KEITH DEVORE, Chief
County Administration Building
827 Seventh Street, Room 301
Sacramento, California 95814
Phone: (916) 440-6851
Fax: (916) 552-8693

March 6, 1997

Dear Water Customer:

Recent tests made on samples of drinking water taken in Sacramento County's Sunrise Service Area Water System have revealed the presence of a chemical known as perchlorate.

Ammonium perchlorate is an inorganic salt used by the defense industry as an oxidizer in solid rocket propellant. Over the years, this chemical has been in use at Aerojet and McDonnell-Douglas. When this chemical seeps into groundwater, the ammonium dissipates, however perchlorate may remain.

Perchlorate is not regulated by the U.S. Environmental Protection Agency and no drinking water standards for it exist. No routine testing for perchlorate is required. In this case, the chemical was detected by special testing undertaken by Aerojet under the direction of the State Water Quality Control Board.

The California Department of Health Services does consider perchlorate to be a "suspect" chemical, which may have an effect on thyroid function, particularly in small children and bottle fed infants. For this reason, they have asked that we discontinue using wells in which perchlorate is present, and that we notify you that you may have had recent exposure to perchlorate through drinking water.

Later this month, the U.S. Environmental Protection Agency will more clearly define its views and standards with respect to the presence of perchlorate.

On Friday, February 28, we ceased supplying water from two affected wells in this service area. Water is now being provided to you from unaffected wells in the Arden Cordova Water District.

Because this supply is limited, you may experience periodic low water pressure. We ask that you use water conscientiously and conservatively. **If additional sources of water cannot be secured, mandatory conservation measures will be adopted.**

A public meeting will be held to provide further information. It will take place at Mills Middle School multi-purpose room, at 10439 Coloma Road, Tuesday March 18, at 6:30 p.m. If you have questions in the meantime, please call me directly at 875-6867.

We are working diligently to secure additional water supplies and are committed to providing you with a reliable supply of high quality water. Please be assured that remains our highest priority.

Sincerely,

John Coppola

John Coppola
Senior Civil Engineer
Water Resources Division

Attachment C

# PERCHLORATE IN DRINKING WATER

MAY 1997

Perchlorate, a chemical used in the manufacture of rocket fuel, was discovered in five drinking water supply wells west and southwest of the Aerojet property in Rancho Cordova in February, 1997. Since that time, the California Department of Health Services (DHS) has been advising the water service companies in order to ensure that the level of perchlorate in drinking water is well below the amount which could cause a health problem. This fact sheet will explain how perchlorate got in the water, what effects perchlorate can have on your health, and how DHS decides about safe levels of perchlorate in drinking water.

## How Did Perchlorate Get in the Drinking Water?

The Aerojet Corporation began manufacturing liquid and solid propellants for rocket systems and assembling and testing the rocket systems in 1951. In 1979, state and federal agencies discovered that perchlorate and a group of chemicals called volatile organic compounds (VOCs) were migrating in the groundwater from the Aerojet site toward the American River. In 1988, Aerojet began removing the shallow groundwater and taking out the VOCs. This treated water was then reinjecting into the deep groundwater at the western edge of the Aerojet property. Since there is currently no treatment for perchlorate, the water that was reinjected still contained perchlorate. The perchlorate-contaminated groundwater has since migrated toward public water supply wells.

State agencies are investigating other potential sources of perchlorate in the area such as the former McDonnell Douglas facility and the Purity Oil Sales facility.

## How Was Perchlorate Discovered in the Drinking Water Wells?

Since Aerojet began reinjecting the treated water, they have been required to test for perchlorate in the groundwater on a regular basis to ensure that it has not migrated off the property. In the past, the levels at which Aerojet was able to detect perchlorate in the water were much higher than the levels at which there could be some type of health effect. Recently, Aerojet changed to a method which detects perchlorate at much lower levels. This method indicated that the levels in some of the drinking water wells were of potential public health concern.

## How Could Perchlorate Affect My Health?

Perchlorate could interfere with the function of the thyroid. At high levels, perchlorate interferes with the production of thyroid hormones and could result in a below normal level of thyroid hormone in the body. This condition is called hypothyroidism. In some cases, the pituitary gland responds to the low level of hormone by producing thyroid stimulating hormone (TSH). This increase in TSH can cause the thyroid gland to become enlarged. People with hypothyroidism can feel sluggish, depressed, cold, or tired. However, these complaints may not necessarily be related to hypothyroidism but could be caused by many other conditions. Thyroid disorders are very common, and are more frequent in females than in males.

At one time, one form of hyperthyroidism (a condition in which the thyroid produces an *above* normal level of thyroid hormone) was treated with perchlorate because it effectively reduces the production of thyroid hormones. A few patients who were treated with perchlorate developed disorders of the blood or immune system. However, there is not enough information to know if these problems were caused by perchlorate.

## Is There a Test to Show If I Have Thyroid Problems?

Yes. There are simple blood tests which can measure the amount of TSH from the pituitary gland and test for the level of thyroid hormone. Most diseases of the thyroid can be treated, so you should contact your physician if you think that you might have a thyroid condition.

## What Happens When I Am No Longer Exposed to Perchlorate?

Although this is highly unlikely, if exposure to perchlorate did have an effect on your thyroid, the thyroid would be able to resume its normal functioning shortly after stopping exposure to perchlorate.

## Is It Safe to Drink Water with Perchlorate?

Based on studies of perchlorate, the Drinking Water Program of the California Department of Health Services has set levels for perchlorate in drinking water that are protective of your health (18 parts of perchlorate per billion parts of water also known as 18 ppb). Even if you are pregnant or have an infant or a child in your home, it is not harmful to use drinking water from the tap.

Currently, there are studies being conducted which will further clarify the safe level for perchlorate in drinking water. Your water company will keep you informed if the perchlorate gets above the health protective level.

No commercially available water filtering system is able to remove perchlorate, but bottled water can be used as a substitute.

## How Did DHS Decide What are the Safe Levels for Perchlorate in Drinking Water?

In 1992 and again in 1995, the US Environmental Protection Agency (USEPA) reviewed all available toxicological data on perchlorate: studies of patients who were being treated medically with perchlorate, and animal studies where rats, mice, or rabbits were given varying amounts of food or water containing perchlorate. The USEPA determined that while there was considerable information about the effects of short-term exposure to perchlorate on the thyroid, there was not enough information about the effects of long-term exposure.

In order to determine a safe level for a given chemical in drinking water, scientists rely on information from health studies. When there is limited information available, scientists include a large margin of safety until there is sufficient information to develop a permanent standard.

DHS set a temporary safe level for perchlorate at 18 ppb. This level includes a 300-fold margin of safety. In other words, this level is 300 times less than the level at which no health effects were observed in prior studies.

In terms of your drinking water consumption:

If your water is reported to contain 250 ppb of perchlorate and you drank 2 liters (8 cups) of that water per day, you would still be taking in an amount of perchlorate that is 20 times lower than the amount at which no health effect was observed. If your water is reported to contain 12 ppb of perchlorate and you drank 2 liters (8 cups) of that water per day, you would still be taking in an amount of perchlorate that is 450 times lower than the amount at which no health effect was observed.

## For More Information

For further information about perchlorate in the drinking water and the health effects:

Steve Book, Ph.D.
Drinking Water Program
California Department of Health Services
(916) 323-6111

Marilyn Underwood, Ph.D.
Environmental Health Investigations Branch
California Department of Health Services
(510) 450-3818

For information about thyroid:

The Thyroid Foundation of America
(800) 832-8321

This publication was supported by funds from the Comprehensive Environmental Response, Compensation, and Liability Act trust fund through a cooperative agreement with the The Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Deaprtment of Health and Human Services and the California Department of Health Services, Environmental Health Investigations Branch.

Attachment D


# COUNTY OF SACRAMENTO

**WATER RESOURCES DIVISION**.....**KEITH DEVORE, Chief**
**Operation and Maintenance Engineering** **Phone: (916) 440-6851**
**9660 Ecology Lane** **Fax: (916) 875-6884**
**Sacramento, California 95827-3881**

**PUBLIC WORKS AGENCY**

*WARREN H. HARADA, Administrator*
PATRICK L. GROFF, Director
Public Works Administration
ROBERT F. SHANKS, Director
District Engineering
CHERYL CRESON, Director
County Engineering


June 20, 1997

Dear Water Customer:

On March 6 we notified you that the chemical perchlorate had been detected in the two wells supplying drinking water to Sacramento County's Sunrise Industrial service area. Perchlorate is a chemical associated with rocket testing and explosives manufacture that at sufficiently high concentration can affect thyroid activity. An emergency booster pump station connecting the County system to the Arden Cordova Water Service was constructed at Sunrise Boulevard and Citrus Road, and the two affected wells were programmed to operate only in the event of very low system pressure. Several significant events have occurred since the beginning of March.

Health Standards

In May, after additional review of study data concerning the health effects of perchlorate, the State Department of Health Services raised the drinking water provisional action level (the level determined to provide adequate health protection) from 4 parts per billion (ppb) to 18 ppb. Additional studies will be done this year, after which it is expected that the U.S. Environmental Protection Agency will adopt a formal drinking water standard for perchlorate in early 1998. A Fact Sheet prepared by the Department of Health Services is attached for your information.

Water Supply

As noted, both the affected County wells have been programmed to pump water only during periods of very high demand when the limited supply from Arden Cordova cannot maintain adequate pressure in the system. In March and April, Well W-18 on Recycle Road pumped intermittenetly and provided less than 1% of the total water used in the service area. However in May, water demand soared with the temperature and nearly 2,000,000 gallons were pumped from Well W-18, 7.3% of the total water used during the month; the perchlorate concentration of this well is 90 ppb.

The peak demand period in the service area generally occurs between midnight and 7 a.m. as the result of irrigation, and it is therefore reasonable to assume that this is how most of the well water is used. Furthermore, the well water is blended in the system with uncontaminated water from Arden-Cordova, thereby reducing the concentration of perchlorate. Nonetheless, it is possible that some of our customers, particularly those close to the Recycle Road Well site, may have been exposed to drinking water with a perchlorate concentration considerably higher than the provisional action level of 18 ppb.

Emergency Projects

Construction of a booster station and four miles of 16-inch pipeline supplying up to 1,200 gallons per minute from the uncontaminated Mather Field housing system began in late May; the target completion date for this work is July 15. The up-front funding for this project is being provided by the Aerojet Corporation.

Conservation

Water demand in the service area increased dramatically when the weather turned hot in May; as a result, Well W-18 has had to pump water to maintain pressure, thereby introducing perchlorate into the system. Our records for the month of June indicate that this well continues to operate intermittently to meet peak water demands, which generally occur between midnight and seven a.m. when irrigation systems are active. Voluntary reduction of irrigation use will reduce the frequency, or even eliminate, the use of Well-18. Our water-waster patrols have been very active in the area citing for violations of the County's Water Conservation Ordinance; the most frequently cited violation has been for broken sprinkler heads which result in a tremendous waste of water. We ask the cooperation of all our customers in reducing their water use during this water supply emergency. July and August are historically the months of highest demand - unless water use is reduced and until emergency projects can be completed, customers face the prospect of low pressure and increased use of the contaminated wells; mandatory restrictions on use with severe penalties for violations may have to be imposed if voluntary reduction is unsuccessful.

We continue to work diligently to secure a reliable high-quality replacement source of water to meet both the short-term and long-term needs of our customers - we have no higher priority. Your cooperation and patience during this period is appreciated. Please call me at (916) 875-6867 if you have any questions.

Sincerely,

John P. Coppola
Senior Civil Engineer
Sacramento County Water Resources Division

# APPENDIX A. RESPONSE TO COMMENTS FROM SITE TEAM REVIEW

In 1995, EHIB formed a site team to assist us in identifying public health concerns and to oversee what we do during the health assessment process for the Aerojet General site. The site team is composed of community residents, state and federal environmental and health agency staff, Aerojet staff, as well as EHIB staff. Health consultations that are produced as apart of the health assessment process are released for comment to site team prior to them becoming final. We received comments on this health consultation from the Drinking Water Branch of CDHS, U.S. EPA, DTSC, Aerojet, and RWQCB. In this appendix, we will respond to the submitted comments. (Some of the commenters used the Cordova Water System Health Consult as the basis for their comments and asked them to be applied to other health consultations when applicable. Thus, some of the comments make reference to the Cordova Water System and not the Sacramento County Sunrise District, but we included the comment in this health consultation if it seemed applicable.)

## COMMENTS RECEIVED FROM THE DRINKING WATER BRANCH OF CDHS

*The Drinking Water Branch of CDHS regulates water purveyors in the state, and their comments were minor technical corrections to the numbers we cited in the text. These corrections were made to the original document.*

## COMMENTS RECEIVED FROM THE U.S ENVIRONMENTAL PROTECTION AGENCY

The EPA offers the following comments for your consideration:

USEPA comment: Page 7 - fourth sentence - the statement that "ammonium perchlorate has relevant physical and chemical characteristics similar to cadmium chloride does not appear to be justified. Although both of these compounds are salts, on dissolution (a necessary step in absorption) perchlorate would become an anion (negative charge) and cadmium would become a cation (positive charge). Therefore, one could conclude on this basis alone that cadmium would not be an appropriate surrogate for perchlorate. Comment applies to all reports but Fair Oaks Water District Report.

*CDHS response: According to a highly regarded dermal absorption reference source, the permeability of charged ions is extremely low and membranes appear to be more permeable to cations than anions* (36). *Thus, the comparison of perchlorate should not be made between the cation, cadmium, but the anion, chloride, that is found when cadmium chloride is in solution.*

USEPA comment: Page 8 - third paragraph - NOAEL term use - The NOAEL is an experimentally derived value that is often used as a basis for the RfD, however, the NOAEL is not regarded by EPA as a value that "would not be expected to be associated with any adverse effect". Rather, this definition better fits the RfD that is derived from a NOAEL after considering uncertainties in the database. Comment applies to all reports but Fair Oaks Water District Report.

*CDHS response: We have corrected the use of NOAEL and RfD in the text.*

USEPA comment: Page 23 -Table 3 - Worker exposure - The tap water ingestion rate for workers is listed as (3.7 liters/day) which is almost twice the assumption that is used for a residential scenario. Should this be 0.37? This applies to Mather Air Force Base Water Service Area Report Table 3 - page 21 and the Sunrise District of the Sacramento County Water Service Report Table 2 - page 18. Also, the Citizens Utilities' Suburban & Security Park Water Service Areas Report Table 3 - page 19 lists worker exposure at 2.0 liters/day should this be 0.37?

*CDHS response: We are using a reference from USEPA document entitled "Exposure Factors Handbook", published in 1989. In this document, the total fluid intake for a moderately active man is cited as being 3.7 liters/day. This document cites the Report of the Task Group on Reference Man from the International Commission on Radiological Protection, published in 1981 for this number. This higher intake of water does seem appropriate given the labor-intensive commercial businesses that are located near the perchlorate-contaminated wells.*

## COMMENTS RECEIVED FROM THE CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL

Below are DTSC's comments which may be considered as the documents are finalized.

DTSC comment: In the "Exposure Pathways" sections of the Arden Cordova, Mather Air Force Base and the Sacramento County water district consultations, it is stated that Aerojet began reinjecting water from their treatment plants on the west boundary of the site in 1984 and 1985. The assumption is then made that it took "a couple of years for the perchlorate to move from the reinjection wells" to the water district's wells. An accurate assessment of when the perchlorate contamination occurred and the location of the source of the perchlorate cannot be made without further information and analysis. The reinjection field nay not be the source of the perchlorate contamination in many of the affected wells. Aerojet is currently investigating the extent of the perchlorate contamination to the west of its facility pursuant to an order from the Regional Water Quality Control Board. A technical memorandum documenting the results of that investigation is currently scheduled to be submitted in May of 1998, with an Engineering Evaluation/Cost Analysis of remedial alternatives to be submitted in October of 1999. Additional investigations of groundwater to the west of the Inactive Rancho Cordova Test Site (IRCTS), the likely source of perchlorate in several of the affected wells, are also proceeding. DTSC's Project Manager for the IRCTS is Mr. Marvin Woods who can be reached at (916) 255-3666.

*CDHS response: EHIB recognizes that a good analysis of the perchlorate migration which would allow us to know when the perchlorate reached the public drinking water supply well, has not yet been done. In fact, we start off the first paragraph in the "Exposure Pathways" section by saying, "It is not clear when the perchlorate contamination reached the Sacramento County Sunrise District wells...". However, since the reinjection of treated water is at least one source*

*of the perchlorate found in some of the drinking water supply wells, we found it was important to share information about this source with the reader. We look forward to reviewing the reports that DTSC is referring to, and hope that they will give a more accurate picture of past well contamination levels.*

DTSC comment: In the third paragraph of the consultations, it is stated that the Regional Water Quality Control Board is the lead regulatory agency. While this is correct for some aspects of the project, the lead regulatory agency controlling water district activities is the Department of Health Services, Office of Drinking Water. For matters concerning the Aerojet Superfund Site, the United States Environmental Protection Agency is the lead federal regulatory agency. A co-lead situation exists for certain matters covered under the Aerojet Superfund Site Partial consent Decree (United States District Court, Eastern District of California, Civil Action Nos. CIVS-86-0063-EJG and CIVS-86-0064-EJG).

*CDHS response: Being a part of the complex government oversight at this site, we appreciate the clarification to the agency responsibilities. We have tried to rectify this in the text.*

COMMENTS RECEIVED FROM AEROJET GENERAL CORPORATION:

Aerojet comment about the attribution of source of the perchlorate in public water supply wells: Each draft Health Consultation assumes that perchlorate being found in public water supply wells came from the Aerojet Operating Plant, specifically from the reinjection wells associated with the GET facilities. There are numerous locations where such references appear. (See, for example, Arden Cordova Health Consultation at:

Page 6, paragraph 2 and page 22, Table 2.) This assumption is used to project length of exposure and concentrations in the wells over time. The conclusion is made for each well, for every water purveyor, regardless of the well's location, chemical concentrations or differing hydrogeological conditions.

We are aware of no detailed evaluation of sources, groundwater conditions and groundwater and contaminant movement undertaken by DHS or any other agency that would support statements in the DHS Consultations that attempt to link perchlorate in a well to an upgradient source, and it does not appear necessary for DHS to ascribe a source to reach its conclusions. The Health Consultations should identify that potential sources of perchlorate include the Aerojet Operating Plant, Purity Oil site, and the McDonnell Douglas (MDC) Site. DHS should not assert that the only source of the perchlorate is the GET facility recharge wells on the Aerojet Operating Plant. Neither should the period of operation of the GET wells form the basis for assumptions of exposure of potential receptors. As the Health Consultations discuss potential sources, it should discuss the various uses of perchlorate, other than in rocket motor manufacturing, such as the use of perchlorate in pyrotechnics (fireworks), explosives and other industrial activities. It should also note that perchloric acid, which is used in various industrial activities, including metal-plating, in

laboratories, and in other operations, when released can result in the formation of perchlorate and its movement into soils and groundwater.

Aerojet believes that there have been no health impacts associated with any exposure to perchlorate in the water supply. If the Health Consultations seek to discuss long term impact by assuming exposure for some period (e.g., 10 years), they can do so without assigning a source, but simply by positing the potential for such exposure (without reference to a source) and developing an exposure assessment.

*CDHS response: These health consultations are written as a part of CDHS's public health review of the impact of the Aerojet General site. Thus, the documents are written in respect to Aerojet General and not to other sites or facilities. We do recognize that perchlorate may have also gotten into the groundwater from sources other than Aerojet and that is why in last sentence of the third paragraph on page 1, we refer to the RWQCB's investigation of "other sources of the perchlorate such as the McDonnell Douglas (now Boeing) and Purity Oil Sales sites."*

Aerojet comment about the toxicology: Aerojet recommends modifications to the discussion on toxicology. We are concerned that the draft consultations do not provide sufficient information about what is known about perchlorate toxicity (thyroid function) and end up, unintentionally, providing a less balanced presentation of the potential for impact and risk. For example, we believe there should be more discussion related to the past use of perchlorate in the treatment of Graves patients and its current use in Europe at very high doses without ill effects. Similarly, we recommend the inclusion of a statement that the mechanism of perchlorate on the thyroid as well as basic thyroid functions are well understood and we believe that the discussion as to exposure associated with children may lead to unnecessary concern and should be changed. Finally, we believe that there ought to be mention of the ongoing studies being conducted at the direction of the Air Force.

*CDHS response: We did provide more information in the toxicology section. For instance, we have added more information about past and current uses of perchlorate and what is known and not known about toxicity to the developing fetus and young child. We did have a reference in the recommendations section about the on-going studies by the Air Force and the Perchlorate Study Group and we have added a sentence in the toxicology section referring the reader to the recommendations section for more information about these studies.*

Aerojet comment about the water system operations: The draft Health Consultations, especially in the background sections, contain statements of fact as to the manner of well and system operation of each water entity over time, including detail on well construction and operation in tables. Aerojet has not had an opportunity to complete an evaluation of the accuracy of such statements. We further note that the factual statements generally do not seem to impact the exposure assessment, as the exposure assessment is based upon an assumed concentration that is not generally associated with the specifics of well interties or well operation. We would recommend the Health Consultations state that the water system information is based on current

understanding unless DHS has had the opportunity to perform a detailed evaluation of the information.

*CDHS response: In each health consultation, we cite the CDHS reports or other reports from which we gained this information. We refer Aerojet to those documents if Aerojet would like to evaluate the accuracy of such statements. We do think it is important to describe for the reader the basic structure of a particular water system; on the other hand, we don't want to add more information then is necessary. We hope that the amount of information we have provided will allow a Sunrise District customer to more easily understand extent of the contamination. By describing the water system information in this document, it also helps us to decide where we might consider follow-up activities, like an exposure dose reconstruction.*

Aerojet comment about the Exposure Conclusions: The draft Health Consultations are based upon a set of assumptions, including assumed receptors, exposure rates, and concentrations. From these assumptions, an assumed dose is calculated and then compared to the provisional RfD. We believe that the Health Consultations should carefully describe each assumption upon which the Health Consultations were based, and clarify that these assumptions have not been fully evaluated. For example, a preliminary assessment of proximity to a well is used to determine the type of "receptor" (e.g., resident, worker), but the exposure does not assume any dilution of water from that well with water from any other well.

*CDHS response: All of the exposure parameters are listed in the table and a Sunrise District customer can look at these exposure parameters and apply them to their own situation. Thus it does not seem necessary to explain distributions of exposure parameters or in any other way describe each assumption.*

With these general comments identified, we now progress to the specifics. We use the Arden Cordova Health Consultation as the template for our comments, and emphasize that typically the same issue exists in the other draft Health Consultations.

Aerojet comment: Page 1, Paragraph 2 and Throughout: The term "perchlorate contamination" is subject to misinterpretation and references should be to "water containing perchlorate" or like phrase.

*CDHS's response: In Webster's New Collegiate Dictionary, it says "contaminate" means "to make impure or unclean". Perchlorate is not typically found in groundwater, as would be the case with certain chemicals like arsenic or sulfates which are naturally occurring in groundwater. Thus it does seem appropriate to describe the "contamination" of groundwater by a chemical such as perchlorate. Likewise, it may be appropriate to describe "water containing arsenic" if you are describing water which contains unusually high levels of arsenic due to natural reasons and arsenic-contaminated water if higher levels than normal may be due to non-natural reasons.*

Aerojet comment: Page 1, Paragraph 3: The description of Aerojet operations and Cordova operations has been taken from earlier documents. Aerojet has historically pointed out the inaccuracies in the statements and rather than do so again we recommend, at a minimum, elimination of a reference to Cordova Chemical Company, because we do not believe it used perchlorate. We also recommend an elimination of the reference to the deep injection wells, because they are not relevant to the issue and can result in confusion when there is later discussion about recharge or reinjection wells associated with the GET facilities, which are different wells.

*CDHS response: In the background paragraph, we are describing the lay of the land regarding the general site issues and thus we did not directly suggest that Cordova Chemical did use perchlorate, but rather this company was a part of the history of the site. Since perchlorate is reinjected at the site boundary as a part of the GET operations, we do not agree that reference to these should be eliminated.*

Aerojet comment: Page 1, Paragraph 3: Delete "property" after "Aerojet's."

*CDHS response: This incorrect grammar has been corrected in the text.*

Aerojet comment: Page 1, Paragraph 3: Aerojet is not reinjecting treated water at the site's northern boundary.

*CDHS response: This has been changed in the text.*

Aerojet comment: Page 1, Paragraph 3: The Regional Water Quality Control Board (RB) is not the lead Agency; DTSC, USEPA and RB together provide oversight pursuant to the Partial Consent Decree.

*CDHS response: The description of the lead agency/agencies was changed in the text.*

Aerojet comment: Page 2, Second Paragraph: The construction of the air-stripper on Well #18 was built by Aerojet and McDonnell Douglas and completed in March 1995.

*CDHS response: The text was revised to reflect this comment.*

Aerojet comment: Page 2, Last Paragraph: Insert the word "improved" prior to "interconnect".

CDHS response: The text was revised to reflect this comment.

Aerojet comment: Page 2, Last Paragraph: Delete "and a booster station to pump the water was constructed by Sacramento County."

*CDHS response: Based on conversations with Sacramento County staff, it seems that the text was correct as it was originally written, thus no changes in the text were made.*

Aerojet comment: Page 3, Paragraph 1: The discussion as to detection of perchlorate ought to be rewritten. Prior to the summer of 1996, Aerojet's laboratory used an ion specific electrode method. In 1997 Aerojet's laboratory did not use a different analytical method for perchlorate analysis to obtain the detection limit of 35 ppb but rather refined or improved the sensitivity of the existing ion chromatography method. In addition, it is accurate to say the "method" detection limit.

*CDHS response: Based on this comment and a similar comment by other reviewers, the description of the analytical method was revised in the text.*

Aerojet comment: Page 4, Paragraph 3: The manner in which the audience was asked to respond, the lack of any information as to what each person who responded intended, and the differences in views as to the percentage of persons responding, makes the reference to the hand raising event questionable in a Health Consultation. We suggest it be deleted. If reference is made, it should point out that the reference is made to indicate potential community concern, not that a health problem exists that is associated with perchlorate. Further, the number of people at the March 1997 meeting who raised their hands to respond to an inquiry about a thyroid problem were not tallied. It would be more correct to say "a number of people in the audience responded."

*CDHS response: Based on another reviewer's comment this statement was revised in the text to state "significant", rather than 80%, but we do not agree that it should be deleted, as it relates to the health concerns of the community that were expressed at a public meeting.*

Aerojet comment: Page 4, Paragraph 4: The letters sent by Aerojet invited attendance to the April meeting.

*CDHS response: We revised the text to reflect this comment.*

Aerojet comment: Page 6, Paragraph 1: See the discussion above regarding the history of perchlorate sampling. It is not accurate to say that the analytical method Aerojet had been using was not sensitive to adequately assess the migration of perchlorate. It would be more accurate to state that Aerojet's historical analytical method's practical quantitation limit (PQL) for perchlorate was 400 ppb. As stated previously, there was no "alternative analytical method" used but the existing method was refined or improved and the PQL lowered.

*CDHS response: According to the third sentence of the comment, the older method was indeed not sensitive enough to detect the perchlorate contamination. We did, however, revise the text to reflect the last two sentences of the comment.*

Aerojet comment: Page 6, Paragraph 2 and following: This paragraph, as well as others below which need not be separately itemized, make an assumption about source and length of exposure which is not presently supportable. See discussion in general comments.

*CDHS response: We realize that historical monitoring of the drinking water wells at low enough detection limits and thus we do not have a good understanding of the migration of perchlorate and past exposures to the Sunrise District customers. We also realize that we have not yet seen any attempts to model the movement of perchlorate based on groundwater flow patterns and perchlorate levels in monitoring wells. Thus in trying to review the past exposures, we are left to make the best assumptions possible.*

Aerojet comment: Page 8, Continuing Paragraph and following: We refer you to the general comments on toxicology above. The draft Health Consultations would be better balanced if there was more discussion related to the use of perchlorate in the treatment of Graves patients and its current use in Europe at very high doses without ill effects. A strong statement that stresses how unlikely it would be to suffer any of these side effects at the levels addressed in the health consultation would be appropriate. In particular, the draft Health Consultations ought to point out that perchlorate has been used successfully and without incident in a fairly large patient population and with a very small number of reports of aplastic anemia even at the very high therapeutic concentrations A statement that the mechanism of perchlorate on the thyroid as well as basic thyroid functions are well understood would help to clarify the presentation. While the provisional RfD is stated as a level in drinking water at 18 ppb, the remaining levels discussed in the document are stated in terms of mg/kg/day. A direct comparison of those doses with the LOAEL/NOAEL and the provisional RfD in the same unit of PPB's would be very useful to give perspective to the dose issue.

*CDHS response: As noted on the response to a General Comment from Aerojet, we did provide more information in the toxicology section. For instance, we have added more information about past and current pharmacological uses of perchlorate and what is known and not known about toxicity to the developing fetus and child. We also added a statement in the toxicological section that equates the dose to the drinking water concentrations.*

Aerojet comment: Page 8, Continuing and Paragraph 1: The discussion of animal studies should be modified. There are animal studies where toxicologists have interpreted a NOAEL [(e.g. Mannisto (1970) and Caldwell (1996)]. As to the reference to children, in two places there is a discussion that suggests that nothing can be said about children. Aerojet is concerned that the reference might leave the reader with the impression that toxicologists do not consider impact to the thyroid as the focus of the evaluation or it might cause the reader to think that toxicologists view the child's thyroid as not understood. It would be more accurate to state that the mechanism of perchlorate intake on the thyroid is understood and that in evaluating the dose, one must evaluate the possibility that the child may have less iodine reserve which must be considered in evaluating how the child's thyroid compensates in comparison to an adult thyroid. However, any reference should also include the fact that all new-borns are routinely tested for thyroid hormone. levels. Aerojet believes that it would be inappropriate for the Health Consultations to be construed as indicating that children are at risk at the provisional RFD or that exposure to the higher concentrations before well shut down would be associated with any health impact.

While it appears in the text, we believe there should be a clear reference both in the toxicology discussion and in the exposure section, that perchlorate is discharged from the body very quickly and that one would not expect to see any continuing impact on the thyroid once the exposure ends.

*CDHS response: See response to previous comment.*

Aerojet comment: Page 8, Paragraph 3: Regarding the discussion of safety factors, various toxicologists believe that the hypothyroid individual would not be a sensitive subpopulation. Also, the Health Consultations should recognize that the sensitive subpopulation factor is already being accounted for with respect to DHS comments on exposure of children.

*CDHS response: Comment noted.*

Aerojet comment: Page 9, Paragraph 3: See discussion above on children. We believe that the two locations of discussion on children should be combined in one location.

*CDHS response: Comment noted.*

Aerojet comment: Page 9, Paragraph 4: Exposure discussion includes the volume of tap water consumed per day in liters and perhaps the inclusion of a unit like the number of 8 oz. glasses per day would benefit the average reader, or public citizen. This could be included in the text and in the Table.

*CDHS response: We have added this information to the text and table.*

Aerojet comment: Page 9, Paragraph 4 and following: While the Health Consultations do note the potential for mixing of water from various sources within the water distribution system, they assume that the person exposed was exposed at the level reported for the well on the date closest to well closure. The Health Consultations should explain that the evaluation uses the assumed concentration at a well to assess impact of a receptor using the well, even though further evaluation may show that mixing and blending of water during water distribution potentially could occur and reduce the estimated level of exposure.

*CDHS response: See previous responses to similar comments.*

Aerojet comment: Page 9, Paragraph 4 and Following: There is the repeated statement that the estimated doses for [identified type of exposure] from well # [identified well number] exceeded the provisional RfD range and a conclusion stating "health effects may have occurred." The phrase "may have occurred" could be misinterpreted as it may suggest a higher level of risk than existed, given the low levels of perchlorate found in relation to the provisional NOAEL described. Given the uncertainty factors associated with the provisional RfD, Aerojet believes that it would be more appropriate for the Consultations simply to conclude that the level was over the RFD and

then follow with a conclusion as to the unlikely nature of any health impact. If DHS does continue to want to use "may have occurred" language, then the "may have occurred" language should be clarified when presented by referring to the key assumptions, the exposure assessment, etc., (e.g., the number of 8 ounce glasses of tap water needed to be consumed). The health consultations should also stress that there is a significant range between the provisional RfD of 18 ppb and the NOAEL level translated to 4900 ppb (assuming a NOAEL of .1 4 mg/kg/day and a 70 kilogram male drinking 2 liters per day). It would also be useful either to change the reference of "uncertainty" factors to "safety" factors or use the term uncertainty (safety) factors" for the benefit of the reader.

*CDHS response: Comment noted.*

Aerojet comment: Page 12, Paragraph 2: See the above comments regarding speculation as to source.

*CDHS response: See previous response to similar comments.*

Aerojet comment: Page 12, Paragraph 4: There are a number of paragraphs that repeat statements made in the exposure section. See discussion above (page 9) relative to language about dose above the RfD. Aerojet does not believe that it is appropriate to conclude that there "may" have been a "health hazard." If language as to hazard is described, it should not be separated from the DHS assumptions about exposure nor should it be stated without the conclusion as to the unlikeliness of any impact. Aerojet further notes that the various Consultations do not always use the same language on "health hazard," and the differences in language do not appear justified (e.g., see Mather page 12 paragraph 3).

*CDHS response: Comment noted.*

Aerojet comment: Page 13, Bullet #3 and Page 14, Bullet #4: The reference should be to the Perchlorate Study Group, not Perchlorate Work Group.

*CDHS response: This has been corrected in the text.*

Aerojet comment: Page 14, Bullet #2: The use of the word "safe" is inappropriate, Reference should be to the provisional RfD.

*CDHS response: We have modified the text so as to remove the word "safe".*

Aerojet comment: References, No. 17. The citation to the authors should be corrected.

*CDHS response: This citation has been corrected.*

Aerojet comment on Table 2: We believe a "source" category for this Table is inappropriate.

Please see general comment above on sources.

*CDHS response: Comment noted.*

Aerojet comment on Figures 1 and 2: The figures are illegible at this size and difficult for the reader to understand. The figures that present chemical distributions were draft figures and were not prepared for the purpose being used and are not reflective of present understanding of groundwater conditions.

*CDHS response: We apologize for the quality of the figures. They are only meant to give the reader a basic layout of the perchlorate flow and the well locations and hopefully, this information is still conveyed with these poor quality figures.*

## COMMENTS FROM THE CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD

Regional Board staffs comments on the documents are supplied below.

RWQCB General Comment: We recommend that the use of the term "contaminated" be selectively used. Contaminated should be used when the water represents a hazard to the public health. In the case of perchlorate, "contaminated" should not be used when discussing concentrations less than 18 ppb. It is even unclear whether the term should be applied to those concentrations that are currently found in some of the groundwater supply wells (up to 300 ppb). Instead of saying "perchlorate-contaminated water", we would recommend saying "water containing perchlorate".

*CDHS response: As was stated under a similar comment raised by Aerojet, in Webster's New Collegiate Dictionary, it says "contaminate" means "to make impure or unclean". Perchlorate is not typically found in groundwater, as would be the case with certain chemicals like arsenic or sulfates which are naturally occurring in groundwater. Thus it does seem appropriate to describe the "contamination" of groundwater by a chemical such as perchlorate. Likewise, it may be appropriate to describe "water containing arsenic" if you are describing water which contains unusually high levels of arsenic due to natural reasons and arsenic-contaminated water if higher levels than normal may be due to non-natural reasons.*

RWQCB General Comment: There is a paragraph in each of the health consultations which discusses the "reporting level to the RWQCB" of 400 ppb and a change in method which allowed for a detection level of 35 ppb. In the early 1990's, up until around 1995/96, Aerojet was using a ionspecific electrode to measure perchlorate concentrations in water with a detection level of 400-500 ppb. Aerojet then developed an alternate method using a GC which provided a detection level of 35 ppb and a reporting level of 400 ppb. This method was then used by Aerojet in all work required under the Partial-Consent Decree. In early 1996 RWQCB staff requested Aerojet to

report all concentrations between the detection level (35 ppb) and reporting level (400 ppb) as trace. Aerojet was then able to lower their PQL to 100 ppb, while maintaining their detection level at 35 ppb. No method changes were made to get to the lower reporting level. It was in February 1996 that the concentrations in the off-site water supply wells were first reported.

*CDHS response: Based on this comment and comments by others, the text was revised.*

RWQCB General Comment: When discussing the nitrate levels, make sure that the values reported are designated as milligrams per liter as nitrate, or milligrams per liter as nitrogen. The MCL for nitrate should be expressed in the same units. There are two values for the MCL used in the five health consultations, 20 and 45 mg/l. A single value for the MCL should be used.

*CDHS response: We have corrected this in the text.*

RWQCB General Comment: We will not supply comments on the toxicological issues presented in the documents. We will rely on the experts at the Department of Health Services to make those evaluations.

*CDHS response: Comment noted.*

RWQCB comment: Page 2, paragraph 5. The value for the MCL for nitrate should be supplied to allow the reader to determine the significance of the values presented.

*CDHS response: We have added the MCL as a reference in the text.*

RWQCB comment: Page 4, paragraph 4. The last sentence refers to "80% of the audience responded". We do not recall that a positive response was so high. We recommend not specifying a percentage, but instead saying that a significant number of the audience responded positively, or something similar.

*CDHS response: Per this comment, we have revised this statement in the text.*

RWQCB comment: Page 6, paragraph 2. There is quite a bit of supposition in the statement that "perchlorate was probably a contaminant in the Cordova System wells since 1987". GET E started injecting in 1985 and GET F did not start injecting until late 1988. Without historical data, it is a stretch to provide a specific date. If the 1987 date remains the uncertainties and assumptions used in deriving that date should be supplied. This comment also applies to the second paragraph of page 12.

*CDHS response: We look forward to the RWQCB or other agencies supplying us with better historical information about the historical movement of perchlorate; in the absence of this, we have clearly stated our guesses as to when perchlorate contamination may have affected drinking water wells.*

RWQCB comment: Page 13, second paragraph. Insert a "the" after "actions" in the second line.

*CDHS response: There was a grammatical problem in the sentence, which we have corrected.*